either personally or by employing competent engineers.

In a large public institution, where steam is required for warming buildings, for heating water for laundry, bath, cooking, and other domestic purposes, and for operating laundry and electric-light engines, pumps and other machinery, the expenditure on fuel is a very important item, and should be the subject of close scrutiny. It is, then, very desirable to ascertain whether the boilers are being worked economically, and, if not, to determine what measures ought to be taken for placing matters upon a proper footing.

It may become necessary to take observations of the flue temperatures and to analyse the gases under different conditions of stoking until a mean has been found giving the smallest possible loss of heat up the chimney.

As some boilers are worked so as to give an efficiency of more than 80 per cent., while others show less than 60 per cent., there is generally a possibility of reducing the waste up the chimney by nearly 20 per cent., thus effecting an economy which, on a coal bill of 300*l*., works out to 60*l*. a year.

The architect is frequently expected to advise his clients on the management of the plant installed under his directions, and for this reason it is desirable that the bearing of management on boiler efficiency should be clearly understood.

If the fire of a boiler be maintained under theoretically perfect conditions, every pound of carbon would require 11·59 lb. of air to ensure its complete combustion, and the weight of the products of combustion would be 12·59 lb. The combustion of 1 lb. of carbon generates 14,540 British thermal units, and, taking the specific heat of the furnace gases at 0·237, the temperature of the flame over that of the air admitted to the furnace will be :—

$$14{,}540 \div (0{\cdot}237 \times 12{\cdot}59) = 4{,}875 \text{ deg. Fahr.}$$

Assuming that, by being passed over the heating surfaces of the boiler, the temperature of the heated gases is reduced to 487·5 deg. Fahr. over that of the air admitted, the heat abstracted by the boiler is 90 per cent. of the total amount generated, only 10 per cent. being wasted up the chimney shaft.

In actual practice, perfect combustion cannot be secured with less than 14 lb. of air per pound of coal. This means that the weight of waste gases is increased to 15 lb., with a corresponding reduction of flame temperature to :—

$$14{,}540 \div (0{\cdot}237 \times 15) = 4{,}091 \text{ deg. Fahr.}$$

Hence, if the gases be cooled down as before to 487·5 deg., the practical efficiency of the boiler becomes :—

$$(4{,}091 - 487{\cdot}5) \div 4{,}091 = 88{\cdot}08 \text{ per cent.}$$

Supposing the stoker admits so much air that the waste products weigh double the theoretical weight, the flame temperature will be :—

$$14{,}540 \div (0{\cdot}237 \times 25{\cdot}18) = 2{,}437{\cdot}5 \text{ deg. Fahr.}$$

But, owing to the lower temperature of the furnace gases, a smaller proportion of the heat will be transmitted through the plates into the water, and it is probable that the final temperature of the gases will be about 600 deg. Fahr.

Consequently, the efficiency of the boiler will be reduced to :—

$$(2{,}437{\cdot}5 - 600) \div 2{,}437{\cdot}5 = 75{\cdot}38 \text{ per cent.}$$

In very bad practice the products of combustion sometimes weigh as much as forty times the weight of the fuel consumed. Then the flame temperature will be further reduced, and the proportion of heat absorbed by the water further decreased, so that the boiler efficiency may drop to about 50 per cent. In such a case half the heat furnished by the coal is literally wasted up the chimney, and, even after making allowance for an inevitable loss of 12 per cent., we have the result that 25 per cent. of the coal burned is wasted by the ignorance of the fireman.

Incomplete combustion, which is usually accompanied by excessive production of smoke, is another cause of reduced efficiency, and is largely due to inadequate supplies of air, especially at times when fresh fuel has been added to the fire. If all the coal used in a boiler were burned so as to produce carbon monoxide (CO), instead of carbon dioxide (CO_2), only 4,340 instead of 14,540 British thermal units would be generated per pound of carbon. Thus the value of the coal would be reduced by two-thirds or more. As a rule, however, the proportion of incompletely-consumed fuel is not large, except in cases of very bad stoking, to which the attention of the owner or manager of a public institution or other establishment should be attracted by the excessive amount of smoke coming from the chimney shaft.

The discussion of other matters affecting the efficiency of steam boilers must be deferred until next week.

OBITUARY.

MR. HAYWARD.—We announce with great regret the death, on July 5, in his seventy-fifth year, of Mr. Charles Forster Hayward, of the Guest Hall, Lingfield, Surrey, and of No. 50, Great Russell-street, W.C., architect, and District Surveyor, London. Mr. Hayward was elected in 1855 an Associate, and in 1861 a Fellow, of the Royal Institute of British Architects, of which he served as member of the Council, and joint honorary secretary with Mr. J. P. Seddon. In 1851 he was elected member of the Architectural Association. Having studied in the Royal Academy schools he became an assistant of P. & P. C. Hardwick, and then began to practise at 8, Adam-street, Adelphi, in association with the late Professor T. Roger Smith, who had been his colleague, with Sir A. Blomfield, C. Eastlake, and G. J. Nicholl, in the Hardwicks' offices. In 1871 Mr. Hayward succeeded the late Charles Fowler as District Surveyor for St. George, Bloomsbury, and St. Giles-in-the-Fields combined parishes; a rearrangement of the district areas having been effected ten years ago, he was appointed District Surveyor for St. Giles-in-the-Fields, St. George, Bloomsbury, St. Martin-in-the-Fields, St. Anne, Soho, and St. Paul, Covent Garden, parishes, with, for a limited period, certain adjoining portions of other parishes, and he filled that office until his death. Of Mr. Hayward's principal architectural works the following have been illustrated, together with plans, in our columns: The Duke of Cornwall Hotel, Plymouth, for the Plymouth Hotel Company (July 4, 1863); St. Andrew's Church, Malden-road, Haverstock Hill, N.W., after the Gothic style (September 14, 1867); "Oaklands," at Halstead, Essex (May 18, 1872); a wooden house, near Christiania (June 21, 1873); the Public Hall, Harrow, for a limited company (January 23, 1875, exterior and interior); for Harrow School: the Sanatorium, with laundry and residential quarters (January 23, 1869), the Gymnasium and Workshops (January 23, 1875, interior), and the Natural Science Schools and Laboratories (December 11, 1886); Christ Church, Zanzibar, for Bishop Steere who superintended the erection of the church on the site of the old slave-market (May 28, 1881); the rebuilding of Nos. 7-8, Bloomsbury-square, W.C. (February 5, 1881); and the large block opposite the British Museum, consisting originally of Russell, the Duke's, and Montague mansions (since modified as Museum-mansions, the Thackeray Hotel, and Great Russell-mansions), together with Nos. 50-51, Great Russell-street, built in 1891-6 between Bury and Museum streets on the site of twenty-two houses in Great Russell-street and Gilbert-street at the rear (April 13, 1895). About forty-five years ago Mr. Hayward formulated a scheme for the reparation of the Church of St. Peter, Colchester; his designs for a reconstruction of the brick-cased tower were partially carried out, and he designed the stone case for the illuminated clock-dials sustained by a projecting ornamental support of Portland stone (March 21, 1896). In 1870 Mr. Hayward was employed as architect for the further alteration and improvement of Nash's Gothic Church of St. Mary in Brunswick-street, Haggerston, N.; and in 1878 (*teste* C. Mackeson's "Guide") for the similar treatment of Coleman's late Gothic Church of St. Philip in New-street, Stepney, E. In the *Builder* of December 29, 1888, is published a drawing of his proposed Clock Tower which the late Mr. George Errington, of Lexden Park, had intended just before his death to erect on the site of St. Runwald's Church, Colchester, since pulled down. Mr. Hayward was architect of the Harrow Local Board Offices and Fire Station (February 17, 1894); of many houses and mansions in London and the provinces, amongst which we may instance a house, for Mr. Baxendale, in Brook-street, Mayfair, and a large half-timbered mansion, Colrennick, near St. Germans, Cornwall, for Mr. Trelawney; "The Firs," Worplesden, Surrey (1886); Copse Hill, for Mr. Brassey; many houses at Halstead; and (including one for himself) at Godalming and the vicinity; several private houses and masters' houses at Harrow; a large hotel at Aberystwith (with Mr. Davies); Nos. 192-4, 258-66, and 242-4, Oxford-street; and Nos. 141-4, Drury-lane, for Messrs. Lambert & Butler, being the last work he did in a private capacity; and he prepared some designs for the St. Giles-in-the-Fields (now Holborn) Public Library. In 1886-7 he carried out the enlargement and improvement of Holy Trinity Church in Little Queen-street (now Kingsway), re-arranging the interior and changing the position of the altar from east to west. His most recent work includes the designs, as a tribute of friendship, for the elaborated Snelgrove memorial chancel-screen in Ilsham St. Matthias Parish Church, Torquay, which is fully described in our number of June 10 last, and he made the designs for the reredos, executed in alabaster and encaustic tiles, in Lawford Church, Essex, in memory of the late Honourable John Robertson, of Lawford-place. Mr. Hayward bestowed much care and labour upon the reinstatement (1897) for his own occupation of the half-timbered house, built in 1431, and known as the Guest Hall, at Lingfield. He restored the church, and wrote a historical account of the Towers at Layer Marney; and made the illustrations for Mr. F. Harrison's book upon Sutton Place, Guildford. Many years ago he perfected a scheme for embanking the Thames between Westminster and Blackfriars, with upper and lower roadways for the Strand and riverside levels. Soon after the opening of the Royal Courts of Justice Mr. Hayward took up the question of making new approaches from High Holborn to the Strand; in the *Builder* of November 18, 1882, will be found his description, and plan, of his projected new streets and communications to serve that object, showing a wide thoroughfare from the end of Southampton-row to a circus at the west end of Portugal-street whence branch two streets to points opposite the churches of St. Mary-le-Strand and St. Clement Danes. Mr. Hayward was a keen antiquarian and archæologist; he was a Fellow of the Society of Antiquaries, a member of Council, London Topographical Society; and in July, 1900, was elected a member of Council, Architectural Museum and Westminster School of Art, being re-elected in the following year. His private practice will be carried on by his son, Mr. A. B. Hayward.

GENERAL BUILDING NEWS.

OWTHORPE CHURCH, NOTTINGHAMSHIRE.—The little Church of St. Margaret, in the village of Owthorpe, three miles from Plumtree Station, has of late years become much dilapidated, and it became necessary that the roof should be overhauled. The work has now been carried out under the superintendence of Messrs. A. W. Brewill, Diocesan Surveyor, and M. B. E. Baily, the contractors being Messrs. Bowman & Sons, Stamford. A flat plaster ceiling has been removed, and the timber roof opened out, such of the timbers as were decayed and rotten have been removed, the whole of the roof tiles removed and the roof retiled, using up all the old tiles that were sound and perfect. The masonry of the windows was also in a defective state, and this has been restored, inserting new stone only where it was absolutely necessary. The lead glazing to the windows has been renewed, using as much of the old glass as possible.

SHINFIELD CHURCH TOWER, BERKS.—The tower of St. Mary's Church, Shinfield, was recently re-opened after restoration. In the tower are six bells—three cast in 1664, one in 1780, one in 1740, and one re-cast in 1803. In 1803 the church bells were taken down and re-hung, after strengthening the tower by putting two bands round the top. In 1863 two more bands were added to the tower from east to west, and an inside arch built to support the west window of the tower. About Easter, 1904, it was intimated to the Vicar by an architect who voluntarily inspected the tower that in his opinion the vibration caused by the six bells was likely to render the tower unsafe, and advised that the peal should not be rung till the defective bell-frame construction had been remedied and the tower strengthened. The Vicar and the Church-wardens elected at the Easter Vestry consulted Mr. S. Slingsby Stallwood, F.S.A., the Diocesan Surveyor, who inspected the tower, and, while expressing his opinion that the ringing of the bells need not necessarily be attended with danger or risk of injury to the structure, advised the overhauling of the gear and the execution of such repair and renewals as might be necessary to secure smoothness of action and minimise the effects of vibration, also the addition to the tower of two ties of iron and belts from north to south, and cutting out some cracks, setting the new brickwork in cement well bonded to the old walling.—*Reading Mercury.*

CATHOLIC CHURCH, WILLINGTON.—On the 5th inst. the new Catholic Church at Willington, near Crook, was dedicated and opened. The cost of the whole erection will be about 4,500*l*. The church, which is in the shape of a cross, is about 90 ft. long, and the breadth is 65 ft.; the dome is 35 ft. high, and the sanctuary has a transept on each side. Rock-faced stone from Dunhouse, Barnard Castle, has been used throughout, and the roof is of pitch-pine and red wood. The windows have been supplied by Messrs. Atkinson, of Newcastle. Adjoining the church is the presbytery, a house of nine rooms. The architects are Messrs. Kelly & Dick, of London. Mr. Hopper, of Wolsingham, was the general contractor.